Development of ductile Cr-Re alloys for high temperature application in aggresive atmosphere

Mechanical, chemical and thermal shock properties
Results overview

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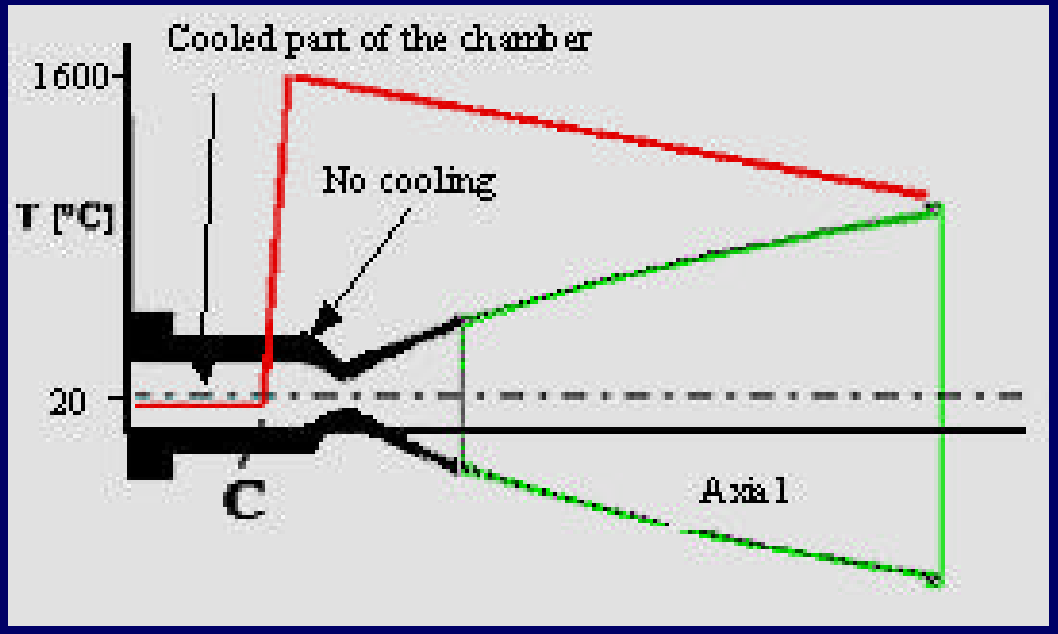
EADS Corporate Research

-Airbus
-Systems and Defence Electronics
-Military Aircraft
-Military Transport Aircraft
-Space

Satellite thruster combustion chambers

Hydrazine based propellants:

- HNO_3 atmosphere at more than 1500 °C
  - 40 at % free nitrogen
  - 2 at % free oxygen
- Longitudinal temperature gradient of 500 K/mm
- Heating kinetics of 500 K/s (700 cycles)



Materials history

1960
Cobalt base
800 °C

1970
Nickel base
1000 °C

1990
Platinum base
1700 °C

Investigated / Qualifyed materials

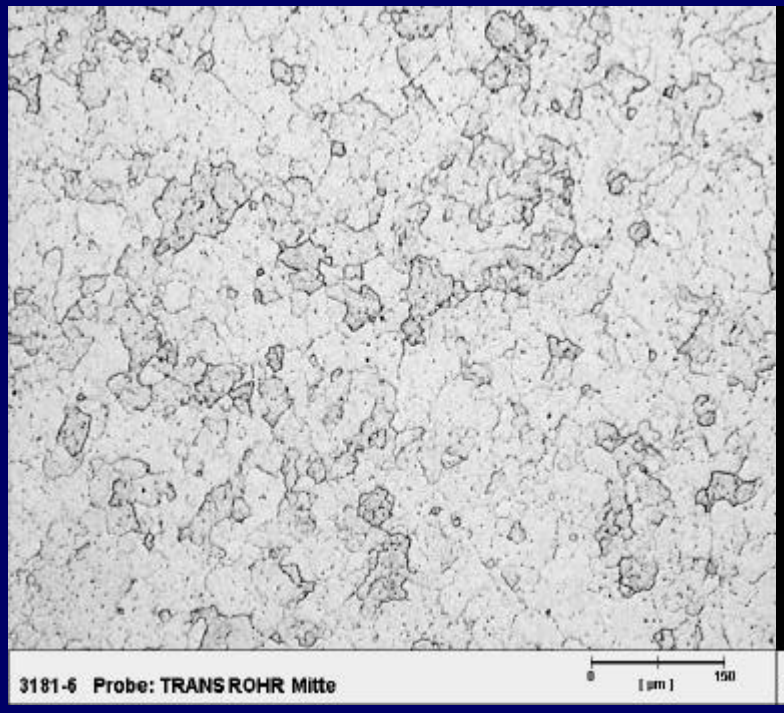
- Qualified materials : Nb coated with quartz
  : Re coated with Ir
- Materials under qualification : Re coated with Ir (PM)
  : Ta/W coated with Re/Ir
- Previous experience at EADS : Ta/W coated with Al_2O_3

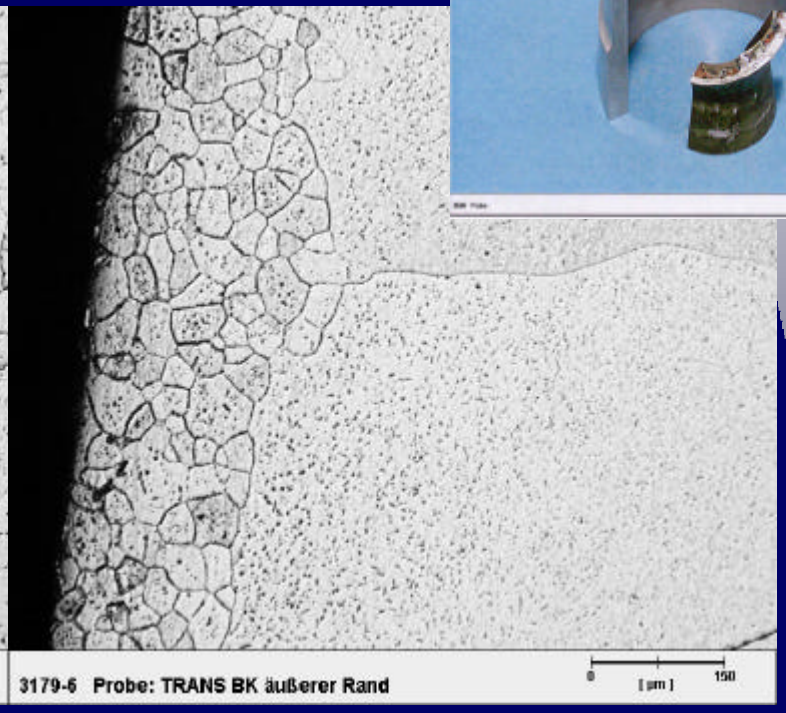
No coating needed
: Pt based alloys, (qualified)
: Cr based alloys

EADS experience with Cr based alloys

Firing experiences (1500 °C) in 1992

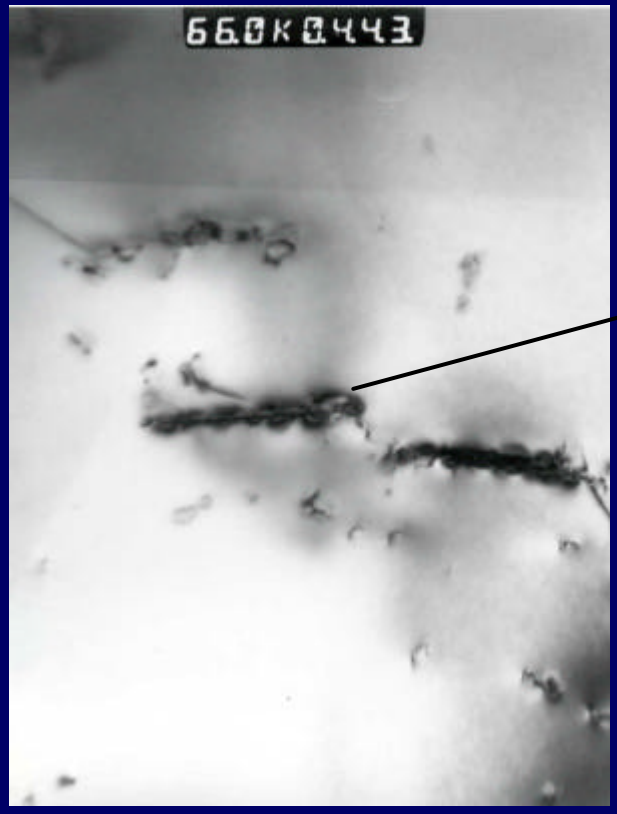
- Brittle fracture due to excessively high DBTT
- Microstructual instability at high T (Rec / GG)

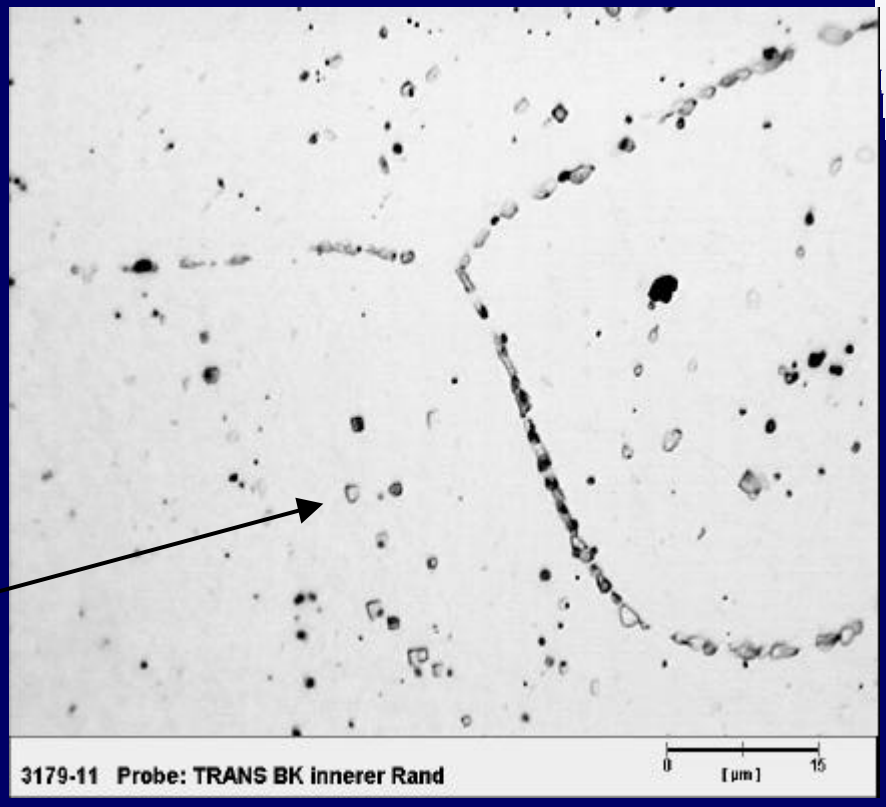




Chemical instability

Precipitation of a second phase in grain boundaries and internal defects



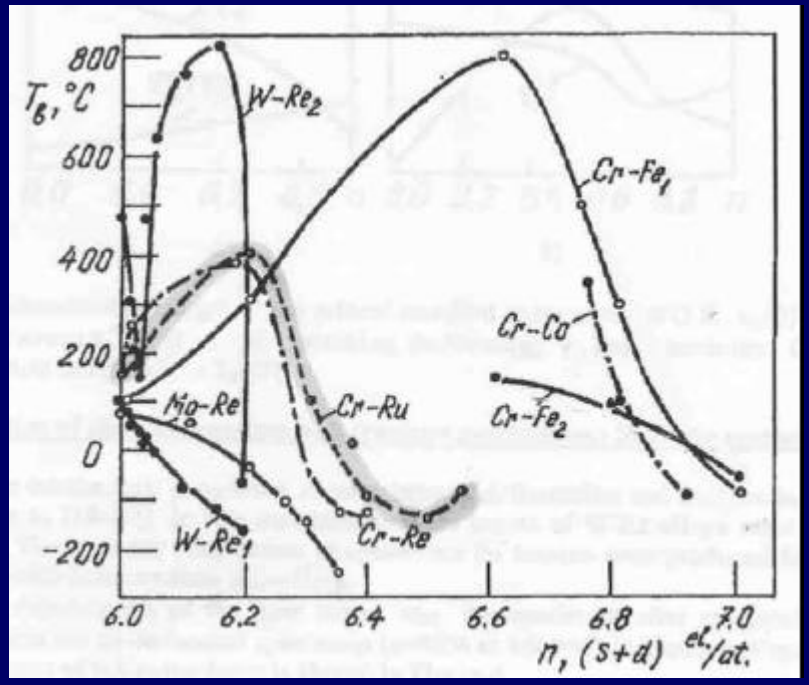


	C	H	O	N
Before	7	2	35	53
After	9	2,5	87	145

The Re effect on BCC refractory metals

- Three Re effects:
  - I Increase of low temperature ductility and strength (VIA)
  - II Increase of the strain hardening rate (VIA)
  - III Increase high temperature strength and creep resistance

- Case of Cr : Increase of recrystallisation T and melting point



No database on the properties of the alloys

Mechanical
Chemical
Thermal

Thermal shock
Particular properties

Systematic study of Cr-Re solid solution alloys

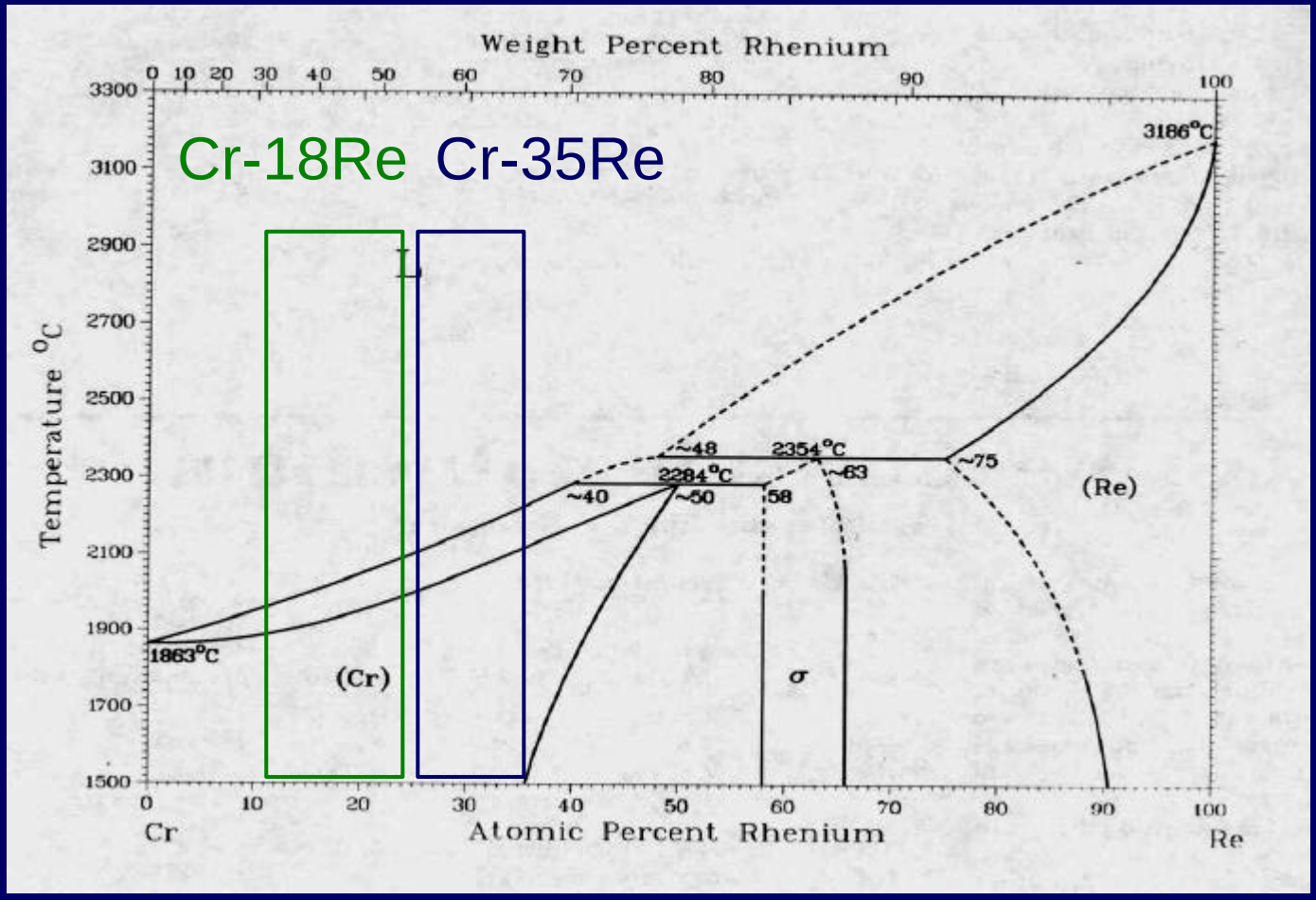
- Selection of a taylored Cr-Re alloy for satellite thruster combustion chambers

  – Manufacturing method

  – Mechanical properties (cryogenic up to 1800 °C)
  – Oxidation/nitridation resistance (up to 1600 °C)
  – Thermoshock and thermal gradient to 500 K/s; 500 K/mm

  – Thermal properties (up to 1600°C)
  – Joining and welding
  – Resistance to propellant
  – Thermomechanical fatigue

The demonstration alloys



Manufacturing method

Powder Metallurgy VS Ingot Metallugy

- Short to mid term: Ingot Metallurgy
  - Prototype alloys by Arc Melting
  - Production by Induction Melting and casting
- Mid to long term: Powder Metallurgy

Arc molten alloys